INTERNATIONAL STANDARD

ISO 19136

First edition
2007-09-01

Geographic information — Geography Markup Language (GML)

Information géographique — Langage de balisage en géographie (GML)

Reference number
ISO 19136:2007(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19136 was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

The Geography Markup Language (GML) was originally developed within the Open Geospatial Consortium, Inc. (OGC). ISO 19136 was prepared by ISO/TC 211 jointly with OGC.

Introduction

Geography Markup Language is an XML grammar written in XML Schema for the description of application schemas as well as the transport and storage of geographic information.

The key concepts used by Geography Markup Language (GML) to model the world are drawn from the ISO 19100 series of International Standards and the OpenGIS Abstract Specification.

A feature is an “abstraction of real world phenomena” (ISO 19101); it is a geographic feature if it is associated with a location relative to the Earth. So a digital representation of the real world may be thought of as a set of features. The state of a feature is defined by a set of properties, where each property may be thought of as a {name, type, value} triple.

The number of properties a feature may have, together with their names and types, is determined by its type definition. Geographic features with geometry are those with properties that may be geometry-valued. A feature collection is a collection of features that may itself be regarded as a feature; as a consequence a feature collection has a feature type and thus may have distinct properties of its own, in addition to the features it contains.

Following ISO 19109, the feature types of an application or application domain is usually captured in an application schema. A GML application schema is specified in XML Schema and can be constructed in two different and alternative ways:

— by adhering to the rules specified in ISO 19109 for application schemas in UML, and conforming to both the constraints on such schemas and the rules for mapping them to GML application schemas specified in this International Standard;

— by adhering to the rules for GML application schemas specified in this International Standard for creating a GML application schema directly in XML Schema.

Both ways are supported by this International Standard. To ensure proper use of the conceptual modelling framework of the ISO 19100 series of International Standards, all application schemas are expected to be modelled in accordance with the General Feature Model as specified in ISO 19109. Within the ISO 19100 series, UML is the preferred language by which to model conceptual schemas.

GML specifies XML encodings, conformant with ISO 19118, of several of the conceptual classes defined in the ISO 19100 series of International Standards and the OpenGIS Abstract Specification. These conceptual models include those defined in:

— ISO/TS 19103 — Conceptual schema language (units of measure, basic types);

— ISO 19107 — Spatial schema (geometry and topology objects);

— ISO 19108 — Temporal schema (temporal geometry and topology objects, temporal reference systems);

— ISO 19109 — Rules for application schemas (features);

— ISO 19111 — Spatial referencing by coordinates (coordinate reference systems);

— ISO 19123 — Schema for coverage geometry and functions.

The aim is to provide a standardized encoding (i.e. a standardized implementation in XML) of types specified in the conceptual models specified by the International Standards listed above. If every application schema were encoded independently and the encoding process included the types from, for example, ISO 19108, then, without unambiguous and completely fixed encoding rules, the XML encodings would be different. Also, since every implementation platform has specific strengths and weaknesses, it is helpful to standardize XML encodings for core geographic information concepts modelled in the ISO 19100 series of International Standards and commonly used in application schemas.

In many cases, the mapping from the conceptual classes is straightforward, while in some cases the mapping is more complex (a detailed description of the mapping is part of this International Standard).

In addition, GML provides XML encodings for additional concepts not yet modelled in the ISO 19100 series of International Standards or the OpenGIS Abstract Specification, for example, dynamic features, simple observations or value objects.

Predefined types of geographic feature in GML include coverages and simple observations.

A coverage is a subtype of feature that has a coverage function with a spatiotemporal domain and a value set range of homogeneous 1- to n-dimensional tuples. A coverage may represent one feature or a collection of features “to model and make visible spatial relationships between, and the spatial distribution of, Earth phenomena” (OGC Abstract Specification Topic 6 [20]) and a coverage “acts as a function to return values from its range for any direct position within its spatiotemporal domain” (ISO 19123).

An observation models the act of observing, often with a camera or some other procedure, a person or some form of instrument (Merriam-Webster Dictionary: “an act of recognizing and noting a fact or occurrence often involving measurement with instruments”). An observation is considered to be a GML feature with a time at which the observation took place, and with a value for the observation.

A reference system provides a scale of measurement for assigning values to a position, time or other descriptive quantity or quality.

A coordinate reference system consists of a set of coordinate system axes that is related to the Earth through a datum that defines the size and shape of the Earth.

A temporal reference system provides standard units for measuring time and describing temporal length or duration.

A reference system dictionary provides definitions of reference systems used in spatial or temporal geometries.

Spatial geometries are the values of spatial feature properties. They indicate the coordinate reference system in which their measurements have been made. The “parent” geometry element of a geometric complex or geometric aggregate makes this indication for its constituent geometries.

Temporal geometries are the values of temporal feature properties. Like their spatial counterparts, temporal geometries indicate the temporal reference system in which their measurements have been made.

Spatial or temporal topologies are used to express the different topological relationships between features.

A units of measure dictionary provides definitions of numerical measures of physical quantities, such as length, temperature and pressure, and of conversions between units.

Geographic information — Geography Markup Language (GML)

1 Scope

The Geography Markup Language (GML) is an XML encoding in compliance with ISO 19118 for the transport and storage of geographic information modelled in accordance with the conceptual modelling framework used in the ISO 19100 series of International Standards and including both the spatial and non-spatial properties of geographic features.

This International Standard defines the XML Schema syntax, mechanisms and conventions that:

— provide an open, vendor-neutral framework for the description of geospatial application schemas for the transport and storage of geographic information in XML;

— allow profiles that support proper subsets of GML framework descriptive capabilities;

— support the description of geospatial application schemas for specialized domains and information communities;

— enable the creation and maintenance of linked geographic application schemas and datasets;

— support the storage and transport of application schemas and datasets;

— increase the ability of organizations to share geographic application schemas and the information they describe.

Implementers may decide to store geographic application schemas and information in GML, or they may decide to convert from some other storage format on demand and use GML only for schema and data transport.

NOTE If an ISO 19109 conformant application schema described in UML is used as the basis for the storage and transportation of geographic information, this International Standard provides normative rules for the mapping of such an application schema to a GML application schema in XML Schema and, as such, to an XML encoding for data with a logical structure in accordance with the ISO 19109 conformant application schema.

2 Conformance

2.1 Conformance requirements

Clauses 7 to 19 of this International Standard specify XML Schema components, i.e. the GML schema, which shall be used in GML application schemas in accordance with Clause 21. Clause 20 specifies rules for the specification of a GML profile that may be defined for use in a GML application schema.

Few applications will require the full range of capabilities described by the GML schema. This clause, therefore, defines a set of conformance classes that will support applications whose requirements range from the minimum necessary to define simple feature types to full use of the GML schema.

Most of the schema components specified in this International Standard implement concepts defined in the ISO 19100 series of International Standards. In these cases, the conformance classes defined in this International Standard are based on the conformance classes defined in the corresponding standard.

Any GML application schema, GML profile or software implementation claiming conformance with one of the conformance classes shall pass all test cases of the corresponding abstract test suite.

Any software implementation claiming conformance to this International Standard shall document the GML profile supported by the implementation. The GML profile shall pass all mandatory test cases of the abstract test suite corresponding to GML profiles.

2.2 Conformance classes related to GML application schemas

GML application schemas claiming conformance to this International Standard shall conform to the rules specified in Clauses 7 to 21 and pass all relevant test cases of the abstract test suite in A.1.

Depending on the characteristics of a GML application schema, 12 conformance classes are distinguished. Table 1 lists these classes and the corresponding subclause of the abstract test suite.

Table 1 — Conformance classes related to GML application schemas

Conformance class	Subclause of the abstract test suite
All GML application schemas	A.1.1
GML application schemas converted from an ISO 19109 application schema in UML	A.1.2
GML application schemas to be converted to an ISO 19109 application schema in UML	A.1.3
GML application schemas defining features and feature collections	A.1.4
GML application schemas defining spatial geometries	A.1.5
GML application schemas defining spatial topologies	A.1.6
GML application schemas defining time	A.1.7
GML application schemas defining coordinate reference systems	A.1.8
GML application schemas defining coverages	A.1.9
GML application schemas defining observations	A.1.10
GML application schemas defining dictionaries and definitions	A.1.11
GML application schemas defining values	A.1.12

2.3 Conformance classes related to GML profiles

The requirements of an application schema determine the XML Schema components from the GML schema that shall be included in a GML profile. GML profiles claiming conformance to this International Standard shall satisfy the requirements of the abstract test suite in A.2.

Depending on the contents and requirements concerning a specific GML profile, 31 conformance classes are distinguished. Table 2 lists these classes and the corresponding subclause of the abstract test suite.

Table 2 — Conformance classes related to GML profiles

Conformance class	Subclause of the abstract test suite
All GML profiles	A.2.1
Geometric primitives (spatial) — 0-dimensional	A.2.2.1.1
Geometric primitives (spatial) — 0/1-dimensional	A.2.2.1.2
Geometric primitives (spatial) — 0/1/2-dimensional	A.2.2.1.3
Geometric primitives (spatial) — 0/1/2/3-dimensional	A.2.2.1.4
Geometric complexes (spatial) — 0/1-dimensional	A.2.3.1.1
Geometric complexes (spatial) — 0/1/2-dimensional	A.2.3.1.2
Geometric complexes (spatial) — 0/1/2/3-dimensional	A.2.3.1.3
Topologic complexes (spatial) — 0/1-dimensional	A.2.4.1.1
Topologic complexes (spatial) — 0/1/2-dimensional	A.2.4.1.2
Topologic complexes (spatial) — 0/1/2/3-dimensional	A.2.4.1.3
Topologic complexes with geometric realization (spatial) — 1-dimensional	A.2.5.1.1
Topologic complexes with geometric realization (spatial) — 2-dimensional	A.2.5.1.2
Topologic complexes with geometric realization (spatial) — 3-dimensional	A.2.5.1.3
Coordinate reference systems	A.2.6
Coordinate operations between two coordinate reference systems	A.2.7
Temporal geometry — 0-dimensional	A.2.8.1
Temporal geometry — 0/1-dimensional	A.2.8.2
Temporal topology	A.2.9
Temporal reference systems	A.2.10
Dynamic features	A.2.11
Dictionaries	A.2.12
Units dictionaries	A.2.13
Observations	A.2.14
Abstract coverage	A.2.15.1
Discrete point coverage	A.2.15.2
Discrete curve coverage	A.2.15.3
Discrete surface coverage	A.2.15.4
Discrete solid coverage	A.2.15.5
Grid coverage	A.2.15.6
Continuous coverage	A.2.15.7

Curve implementations, for those GML profiles including 1-dimensional spatial geometry objects, shall always include a “linear” interpolation technique. Surface implementations, for those GML profiles including 2-dimensional spatial geometry objects, shall always include a “planar” interpolation technique. Additional curve and surface interpolation mechanisms are optional but, if implemented, they shall follow the definition included in this International Standard.

NOTE 1 Compare these conformance classes with ISO 19107:2003, Clause 2, ISO 19108:2002, 2.2, and ISO 19123:2005, Clause 2.

NOTE 2 A GML profile conforming to the three conformance classes “Geometric primitives (spatial) — 0-dimensional”, “Geometric primitives (spatial) — 0/1-dimensional”, and “Geometric primitives (spatial) — 0/1/2-dimensional” (in addition to conformance class “All GML profiles”) conforms to the spatial profile defined in ISO 19137:2007 and the respective conformance tests in ISO 19137:2007, B.1, B.2 and B.3.

2.4 Conformance classes related to GML documents

GML documents claiming conformance to this International Standard shall conform to the rules specified in Clauses 7 to 21 and pass all relevant test cases of the abstract test suite in A.3.

2.5 Conformance classes related to software implementations

Software implementations reading or writing GML or GML application schemas claiming conformance to this International Standard shall pass all of the corresponding abstract test suites described in the abstract test suite in Annex B.

Depending on the capabilities of the implementation, 11 conformance classes are distinguished. Table 3 lists these classes and the corresponding subclause of the abstract test suite.

Table 3 — Conformance classes related to implementations

Conformance class	Subclause of the abstract test suite
All software implementations	B.1
Support for remote simple Xlinks	B.2.1
Support for extended Xlinks	B.2.2
Support for nillable properties	B.2.3
Support for units of measurement	B.2.4
Support for ownership semantics of properties	B.2.5
Metadata properties	B.2.6
Support for GML profiles in instance validation	B.2.7
Writing GML	B.3
Reading GML	B.4
Writing GML application schemas	B.5
Reading GML application schemas	B.6

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8601, *Data elements and interchange formats — Information interchange — Representation of dates and times*

ISO/IEC 11404:1996, *Information technology — Programming languages, their environments and system software interfaces — Language-independent datatypes*

ISO/TS 19103:2005, *Geographic information — Conceptual schema language*

ISO 19107:2003, *Geographic information — Spatial schema*

ISO 19108:2002, *Geographic information — Temporal schema*

ISO 19109:2005, *Geographic information — Rules for application schema*

ISO 19111:2007, *Geographic information — Spatial referencing by coordinates*

ISO 19115:2003, *Geographic information — Metadata*

ISO 19118:2005, *Geographic information — Encoding*

ISO 19123:2005, *Geographic information — Schema for coverage geometry and functions*

ISO/TS 19139, *Geographic information — Metadata — XML schema implementation*

ISO/IEC 19757-3, *Information technology — Document Schema Definition Languages (DSDL) — Part 3: Rule-based validation — Schematron*

ISO 80000-3, *Quantities and units — Part 3: Space and time*

IETF RFC 2396, *Uniform Resource Identifiers (URI): Generic Syntax* (August 1998)

W3C XLink, *XML Linking Language (XLink) Version 1.0*, W3C Recommendation (27 June 2001)

W3C XML, *Extensible Markup Language (XML) 1.0 (Third Edition)*, W3C Recommendation (4 February 2004)

W3C XML Namespaces, *Namespaces in XML*, W3C Recommendation (14 January 1999)

W3C XML Schema Part 1, *XML Schema Part 1: Structures*, W3C Recommendation (2 May 2001)

W3C XML Schema Part 2, *XML Schema Part 2: Datatypes*, W3C Recommendation (2 May 2001)

4 Terms and symbols

4.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1.1
application schema
conceptual **schema** for data required by one or more applications

[ISO 19101:2002]

4.1.2
association
semantic relationship between two or more classifiers that specifies connections among their instances

[ISO/IEC 19501:2005:]

4.1.3
attribute <XML>
name-value pair contained in an **element**

NOTE In this document an attribute is an XML attribute unless otherwise specified. The syntax of an XML attribute is “Attribute::= Name = AttValue”. An attribute typically acts as an XML element modifier (e.g. <Road gml:id = “r1” />; here gml:id is an attribute).

4.1.4
boundary
set that represents the limit of an entity

[ISO 19107:2003]

4.1.5
child element <XML>
immediate descendant **element** of an **element**

4.1.6
closure
union of the **interior** and **boundary** of a **topological** or **geometric object**

[ISO 19107:2003]

4.1.7
codelist
value domain including a code for each permissible value

4.1.8
codespace
rule or authority for a code, name, term or category

EXAMPLE Examples of codespaces include dictionaries, authorities, codelists, etc.

4.1.9
composite curve
sequence of **curves** such that each **curve** (except the first) starts at the end point of the previous **curve** in the **sequence**

[ISO 19107:2003]

NOTE A composite curve, as a set of direct positions, has all the properties of a curve.

4.1.10
composite solid
connected **set** of **solids** adjoining one another along shared **boundary surfaces**

[ISO 19107:2003]

NOTE A composite solid, as a set of direct positions, has all the properties of a solid.

4.1.11
composite surface
connected **set** of **surfaces** adjoining one another along shared **boundary curves**

[ISO 19107:2003]

NOTE A composite surface, as a set of direct positions, has all the properties of a surface.

4.1.12
coordinate
one of a **sequence** of n numbers designating the position of a **point** in n-dimensional space

[ISO 19111:2007]

NOTE In a coordinate reference system, the n numbers shall be qualified by units.

4.1.13
coordinate reference system
coordinate system that is related to an object by a **datum**

[ISO 19111:2007]

4.1.14
coordinate system
set of mathematical rules for specifying how **coordinates** are to be assigned to **points**

[ISO 19111:2007]

4.1.15
coordinate tuple
tuple composed of a sequence of **coordinates**

[ISO 19111:2007]

4.1.16
coverage
feature that acts as a function to return values from its range for any **direct position** within its spatial, temporal or spatiotemporal **domain**

[ISO 19123:2005]

4.1.17
curve
1-dimensional **geometric primitive**, representing the continuous image of a line

[ISO 19107:2003]

NOTE The boundary of a curve is the set of points at either end of the curve. If the curve is a cycle, the two ends are identical, and the curve (if topologically closed) is considered to not have a boundary. The first point is called the start point, and the last is the end point. Connectivity of the curve is guaranteed by the "continuous image of a line" clause. A topological theorem states that a continuous image of a connected set is connected.

4.1.18
data type
specification of a value **domain** with operations allowed on values in this **domain**

[ISO/TS 19103:2005]

EXAMPLE Integer, Real, Boolean, String, Date (conversion of data into a series of codes).

NOTE Data types include primitive predefined types and user-definable types. All instances of a data type lack identity.

4.1.19
datum
parameter or set of parameters that define the position of the origin, the scale, and the orientation of a coordinate system

[ISO 19111:2007]

NOTE A datum may be a geodetic datum, a vertical datum, an engineering datum, an image datum or a temporal datum.

4.1.20
direct position
position described by a single **set** of **coordinates** within a **coordinate reference system**

[ISO 19107:2003]

4.1.21
domain
well-defined **set**

[ISO/TS 19103:2005]

NOTE 1 A mathematical **function** may be defined on this set, i.e. in a function f:A→B, A is the domain of the function f.

NOTE 2 A domain as in domain of discourse refers to a subject or area of interest.

